# Testing and Research Platform for Advanced X-ray Applications

## New insights into material characterization
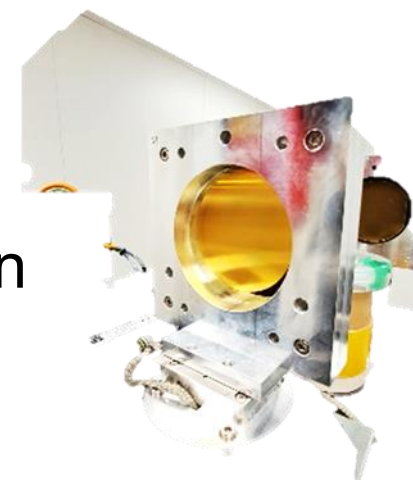
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# X-ray radiation protection cabin

**Advantages:**

- Walk-in radiation protection cabin with large experimental platform.

- Open, Python-based software.

- Enables integration of additional detectors and X-ray sources, or control of in-situ experiments.

- Integration and control of a Talbot-Lau grating interferometer (TLGI).

- TLGI: delivers three contrast modes: conventional absorption (AC), differential phase (DPC) and dark-field (DFC).

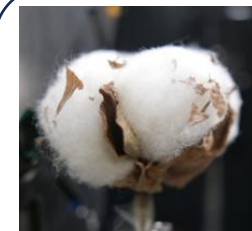- Limitations of conventional X-ray CT are overcome.
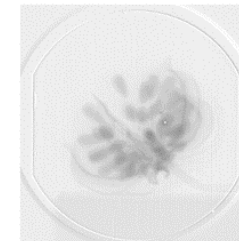


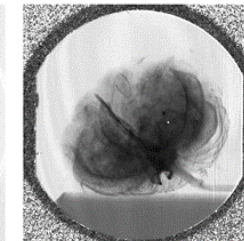Size: 4500 × 2500 × 2200 mm
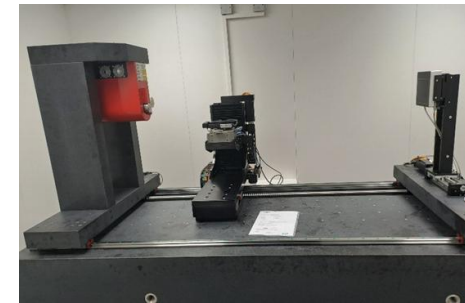


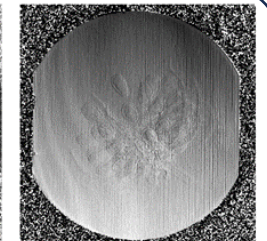Size: 2500 × 1000 × 400 mm



TLG-Interferometer



Cotton-seed

AC

DFC

DPC

# X-ray radiation protection cabin: Optical Setup

**Sample manipulator**

- High-precision, air-bearing rotation stage.

- Two translational degrees of freedom on and two below the rotation axis,

- enables the measurement of relevant areas outside the axis of rotation.

**Properties of the X-ray source**

- Maximum voltage 150 kV / 75 W.

- Focal spot size / resolution => 3 μm.

**Properties of the X-ray detector**

- Flat-panel detector; detector size 140 x 120 mm.

- Measuring field extension to 280 x 240 mm.

- Max. component size 250 x 220 mm.

- Read-out rate at least 40 fps.

# X-ray radiation protection cabin: Image Analysis

**VG-STUDIO MAX 2025/2**

**T-bracket**

- Short-fiber injection molding
- Outer shape: CAD vs. CT Data (a)
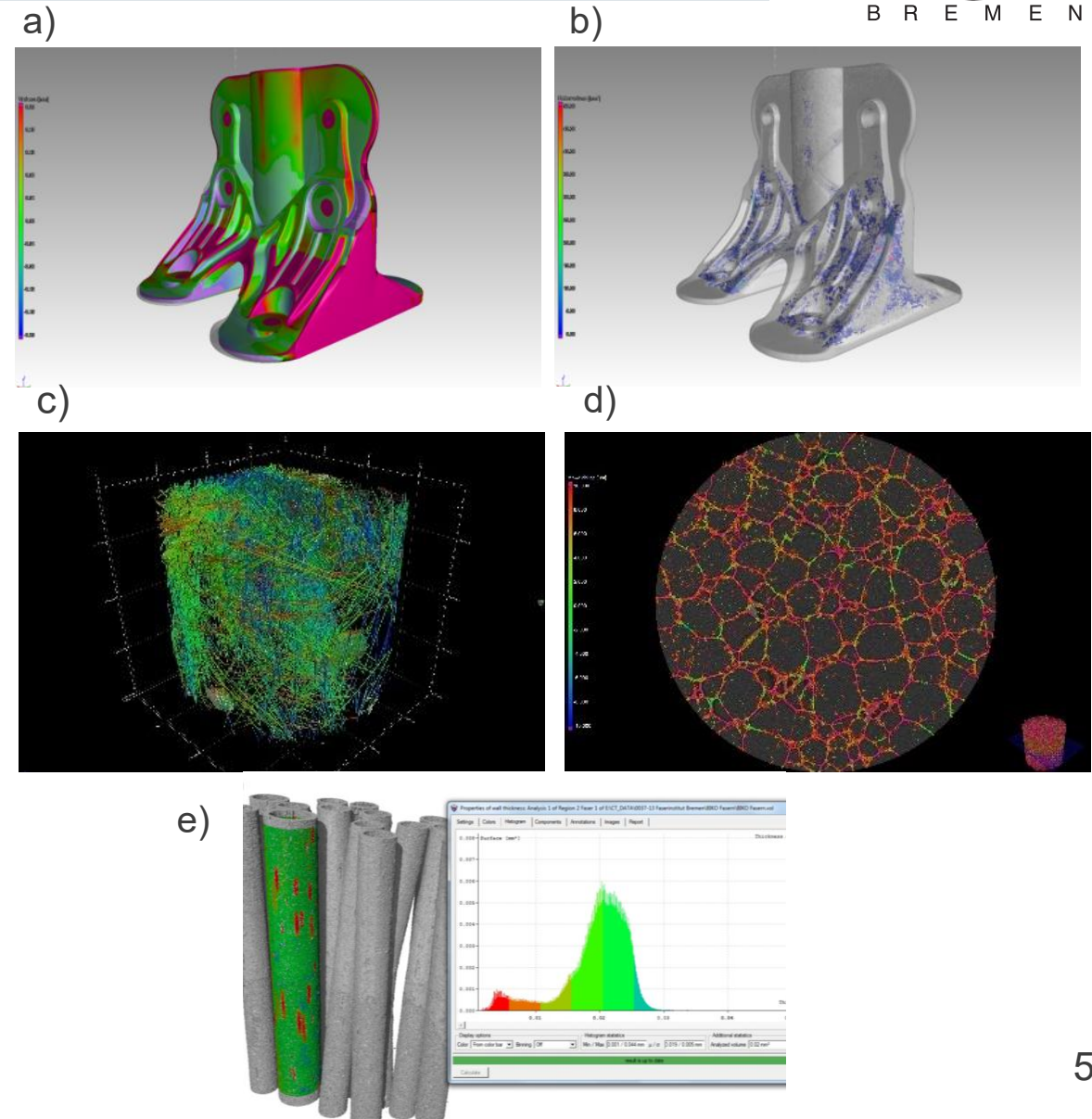- Inner quality: pores (b)

**Non-woven fabric (natural fibers)**

- Color-coded fiber-orientation (c)

**Foam**

- Color-coded displacement comparison (loaded vs. unloaded) (d)
- Digital volume correlation (in-situ-application)

**Bi-component polymer fiber**

- Color-coded wall thickness
- Fiber-diameter 200µm (e)
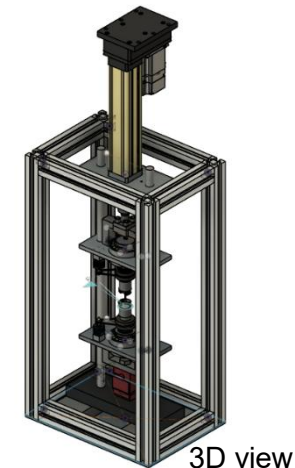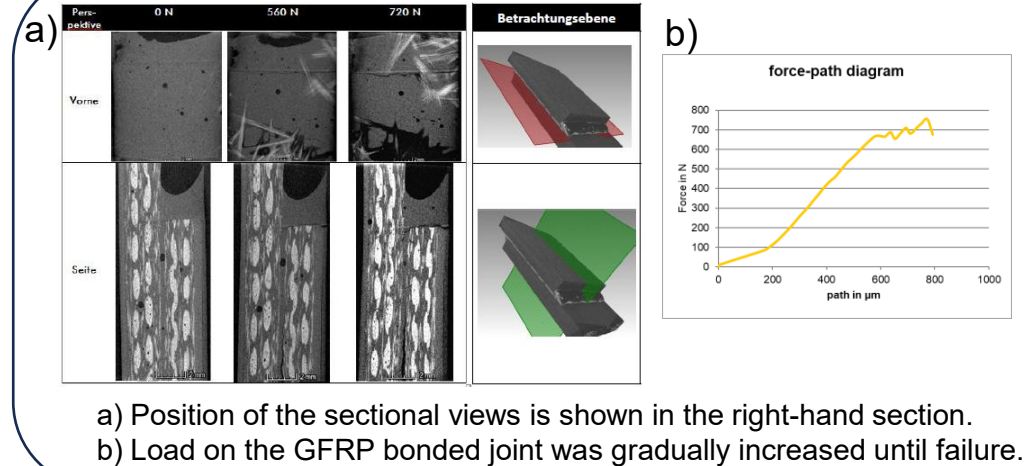


a)

b)

c)

d)

e)

# X-ray radiation protection cabin: Experimental Platform

**In-Situ Experiments:**

- Compression, tensile, and 3- / 4-point bending tests

- Failure testing of bonded joints (a).

- Real-time crack detection based on acoustic emission (AE).

- Further customized experiments possible

  - E.g. thermal loading,

  - Environmental chamber for long term creep-studies,

  - …



a) Position of the sectional views is shown in the right-hand section.
b) Load on the GFRP bonded joint was gradually increased until failure.



- newly designed, revised in-situ unit
- specimen's field of view is unrestricted
- acoustic emission

3D view

# Talbot-Lau-Grating Interferometer (TLGI)

**Software (RosCT, EZRT)**

- Standardized measurement software for CT and TLGI mode

- Reconstruction software for

  – CT applications

  – phase-contrast tomography

  – dark-field tomography

- Python based

**Interferometer**

- Quick switch between X-CT and TLGI mode

# Talbot-Lau-Grating-Interferometer (TLGI)

**Interferometer setup**

- Three line gratings ($G_o$, $G_1$ and $G_2$),

- $G_1 - G_2$ are arranged at a fixed distance (Talbot-Lau configuration)

- $G_2$ can be moved stepwise perpendicular to the optical axis

- realizes a phase shift

- leads to three contrast modes being achieved from a <u>single</u> measurement:

  - Conventional Absorption Contrast (AC)
  - Differential Phase Contrast (DPC)
  - Dark Field Contrast (DFC)





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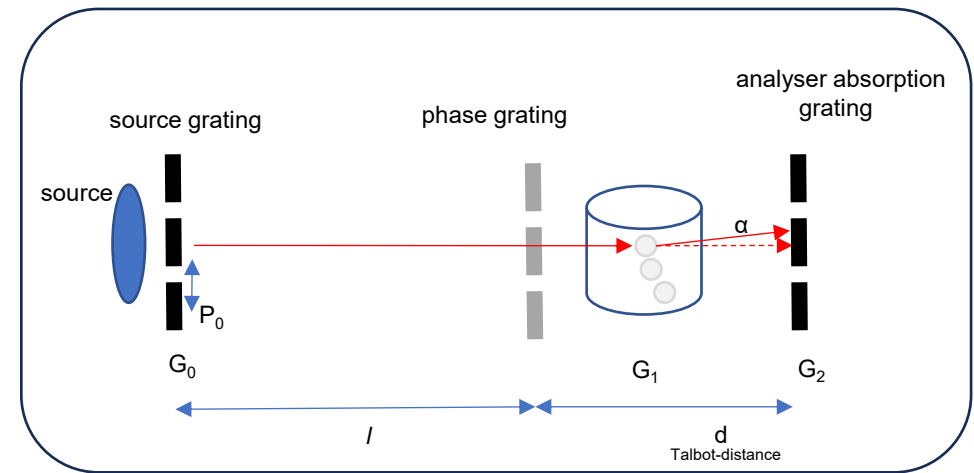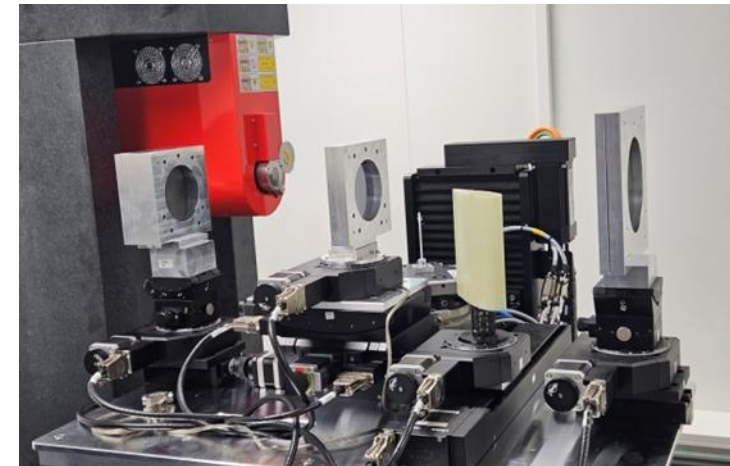
# Talbot-Lau-Grating-Interferometer: Contrast Modes

**Contrast Modes and Applications**

- **AC:** conventional X-ray imaging.

- **DPC:** differentiation of materials with similar attenuation.

- **DPC:** reduced sensitivity to metal artifacts in CFRP components.

- **DFC:** detection of microstructural scattering (pores, fibers, cracks).

- High sensitivity to delaminations and fiber orientation.

- Measurement volume up to 40 mm³.

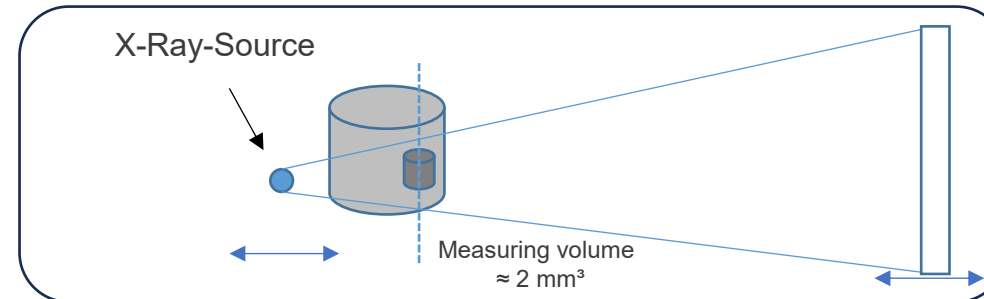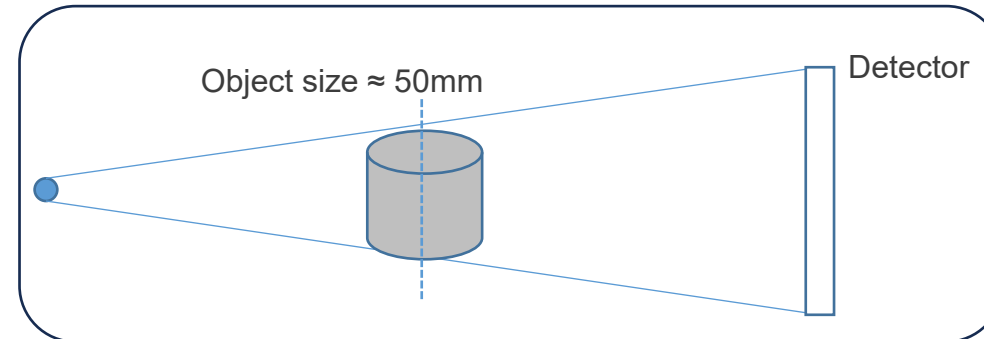- **Conventional CT:** measurement volume limited to 2 mm³.
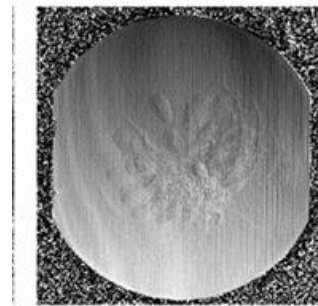


AC
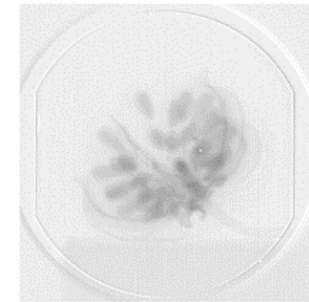
DPC
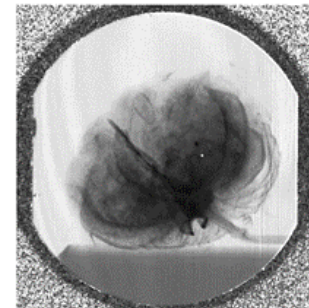
DFC



**Cotton-Seed**

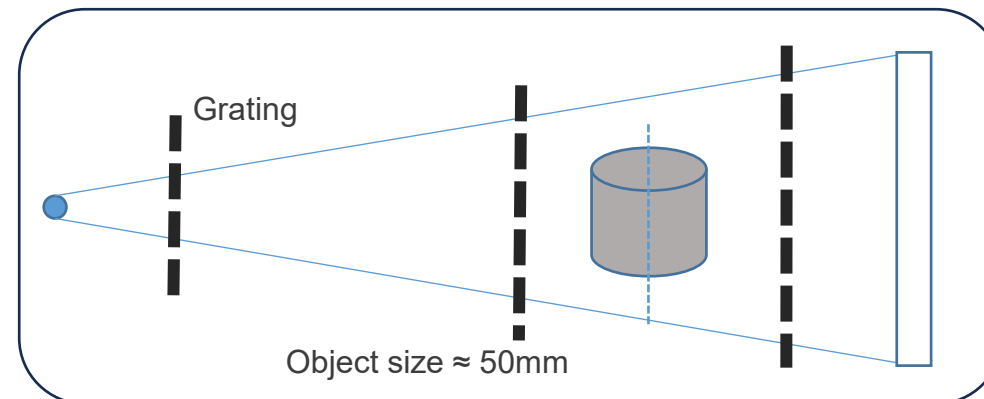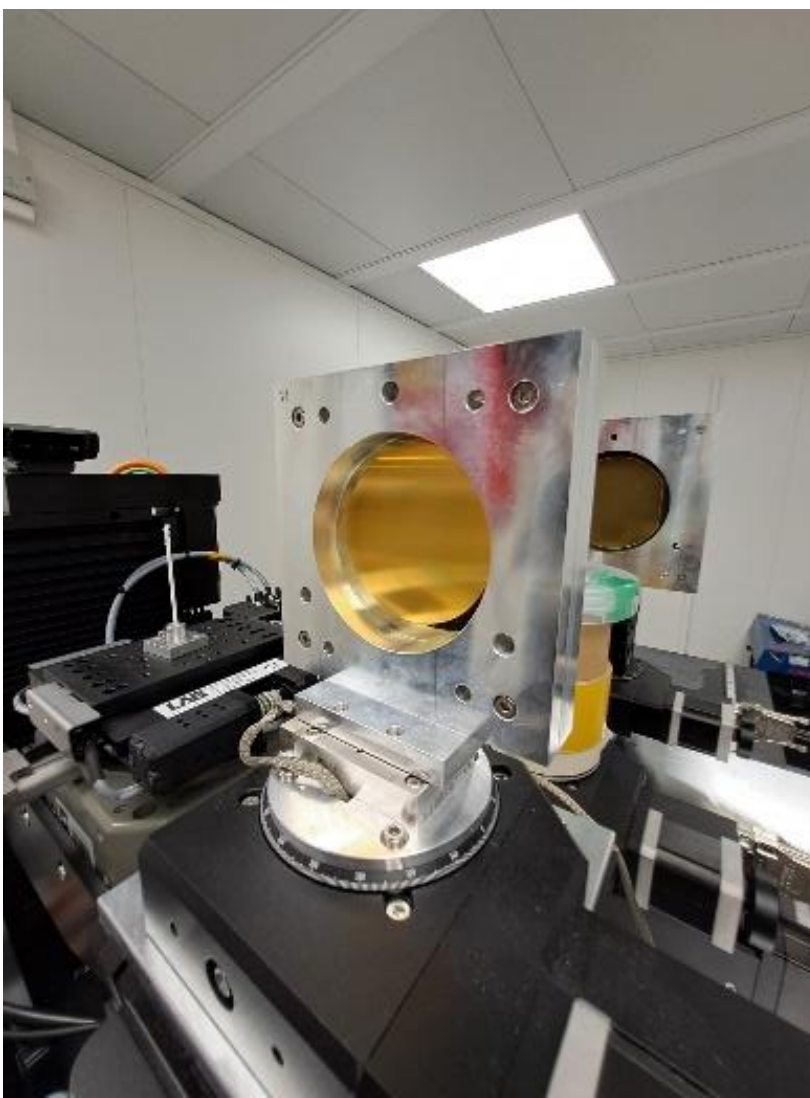# X-ray radiation protection cabin: Measuring modes

**CT Mode**

- Geometrical magnification

- Meso and macro ranges

- Structure and pore analysis

- Flexible region-of-interest measurement

- In-situ experiments

**TLGI / XTT**

- X-ray tensor tomography (XTT)

- Sensitive to micro-cracks and

- Fiber orientation



Object size ≈ 50mm — Detector

X-Ray-Source — Measuring volume ≈ 2 mm³

Grating — Object size ≈ 50mm

Ready to collaborate?

We offer:

- Research services and contract measurements.

- Collaborative development projects.

- Individual consulting for customized applications

Contact us:
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